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On the Geology of Eastern New England; by Dr. T. Sterry Hunt, F.R.S. (From a letter to Prof. James D. Dana.

When, more than twenty years since, my attention was turned to the geology of New England, there was no evidence of the existence between the old gneisses of the Adirondacks and the coal measures, of any other stratified rocks than those of the Huronian series, and the New York system, from the Potsdam formation, upward. It is true that Emmons had, before that time, maintained the presence, in western Vermont and Massachusetts, of a system of fossiliferous sediments, lying unconformably beneath the Potsdam, but the evidence up to this time adduced with regard to these so-called Taconic rocks, has failed to show that they include any strata more ancient than the Potsdam, while most of them are certainly younger. The researches of Sir William Logan, up to 1848, had led him to refer to a period not older than the Lower Silurian the crystalline sediments of the Appalachian region of Canada, between Lake Champlain and Quebec. These form a chain of hills, the continuation of the Green Mountains, and were found by him to be followed immediately, to the southeast, by more or less calcareous and somewhat altered strata, associated with Upper Silurian fossils, and succeeded, across the strike, near the sources of the Connecticut River, by a series, several miles in breadth, of micaceous schists and quartzose strata, occasionally containing

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chiastolite, garnet and hornblende. These two series of rocks, extending from the base of the Green Mountains to Canaan on the Connecticut, it was suggested by Sir William Logan, in his Report on the Geological Survey, 1847–1848, might be the altered representatives of the rocks of Gaspé, including the Lower Helderberg group, and the succeeding members of the New York system to the top of the Chemung. I then, as now, conceived that these micaceous and argillaceous schists, often holding garnets and chiastolite, were identical with those which make so conspicuous a figure in the White Mountains, and elsewhere in Eastern New England, and when, in 1849, I laid before the American Association at Cambridge, the results of the Geological Survey of Canada (this Jour., II, ix, 19), suggested that to the Gaspé series, as above defined, "may perhaps be referred, in part, the rocks of the White Mountains." Lesley, subsequently, in 1860 (Proc. Philad. Acad. Nat. Sciences, page 363), adduced many reasons for believing that the rocks of these mountains might be strata of Devonian age.* In the large geological map of Canada and the northern United States, lately published by Sir William Logan, no attempt is made to delineate the geology of New Hampshire, but the rocks in question, to the north of the United States boundary, are represented as Upper Silurian, with the exception of a belt of the Quebec group, which has been recognized in that region.

In fact, the schists and gneisses of the White Mountains are clearly distinct, lithologically, from the Laurentian, the Labradorian and the Huronian, as well as from the crystalline rocks of the Green Mountains, and from the fossiliferous Upper Silurian strata which lie at the southwestern base of the Canadian prolongation of the latter. Having thus exhausted the list of known sedimentary groups up to this horizon, it was evident that the crystalline strata of the White Mountains must be either (1) of Devonian age, or (2) something newer (which was highly improbable); or (3) must belong to a lower and hitherto unknown series. In the absence of any proof, at that time, of the existence of such a lower system, the first view, which referred these strata to the Devonian period, was the only one admissible.

* In this connection should be recalled the views put forth in 1846, by Messrs. H. D. and W. B. Rogers, in a paper on the Geological Age of the White Mountains, (this Journal, II, i, 411). They there, for the first time, pointed out that the great mass of these mountains consists of more or less altered sedimentary strata, which, upon the evidence of supposed organic remains they referred, with some little doubt, to the Clinton division of the Upper Silurian. In 1847, however, they announced that the supposed fossils, on which this identification had been founded, were not really such, (this Journal, II, v, 116). Future explorers may, it is hoped, be more successful, and yet discover among the strata of the White Mountains evidences of organic life, probably of primordial Silurian age.

When, however, further investigation showed that the great and progressive thickening which takes place in the paleozoic formations from the west, eastward, is not confined to the augmentations of existing subdivisions, but includes the intercalation of new ones; when the few hundred feet of typical Potsdam sandstone in New York are represented in Vermont, Quebec and Newfoundland, by thousands of feet of strata lithologically very unlike the type; while the Quebec group, not less in volume, appears representing the beds of passage between the Calciferous and Chazy divisions of New York, we begin to conceive that conditions of sedimentation, very unlike anything hitherto suspected in the west, prevailed to the eastward. When, moreover, we find widely separated areas of Labradorian and Huronian rocks,—remaining fragments of great series,—resting upon the Laurentian, from Lake Huron to Newfoundland, we get evidences of a process of denudation in past ages, not less remarkable than the sedimentation.

My observations of last year have led me to a conclusion, which had previously been taking shape in my mind, that there exists above the Laurentian, a great series of crystalline schists, including mica-slates, staurolite and chiastolite-schists, with quartzose and hornblendic rocks, and some limestones, the whole associated with great masses of fine-grained gneisses, the so-called granites of many parts of New England. The first suggestions of this were given me by the observation of Dr. Bigsby, confirmed by specimens since received from the region, that there exists to the northwest of Lake Superior, an extended series of crystalline schists, unlike the Laurentian, and resembling those of the White Mountains. I have already called attention to this resemblance in a review of the progress of American Geology, in 1861 (this Jour., II, xxxi, 395). It was contrary to my notions of the geological history of the continent to suppose that rocks of Devonian age could, in that region, have assumed such lithological characters, and I was therefore led to compare these rocks with a great series of crystalline schists, abounding in mica-slates and micaceous limestones, which occupy considerable areas in the Laurentian region in Hastings county, to the north of Lake Ontario. The distribution of this series has been traced out by Mr. Vennor, who, in 1869, was able to show that, although much contorted, it rests unconformably upon the old Laurentian gneisses, while it is, at the same time, overlaid by the horizontal limestones of the Trenton group. This intermediate series, which attains a thickness of several thousand feet, is terminated by calcareo-micaceous schists, in which *Eozoon Canadense* has been found, both in Madoc and in Tudor. In these localities, as shown by Dawson and Carpenter (this Jour., II, xliv, 367), the calcareous

skeleton of the Eozoon, instead of being injected by serpentine or another silicate, is simply filled with impure calcareous and carbonaceous matter. The presence of this fossil serves to connect these rocks with the Laurentian system, with which they had provisionally been classed, although their lithological dissimilarity had long been noticed, and in 1866 Sir William Logan had remarked their resemblance to the mica-slate series found near the sources of the Connecticut River (Report Geol. Survey, 1866, p. 93).

Mr. Alex. Murray's report of his explorations in Newfoundland, published in 1866, throws much light on the history of the rocks immediately succeeding the Laurentian in that region. He found in the great northern peninsula, about the Cloud Mountains and Canada Bay, not less than 5400 feet of strata, referred by him to the Potsdam group. Of these the lower 2500 feet consist of bluish-gray slates, holding near the summit, beds which become conglomerate from the presence of quartz pebbles, and are followed by a mass of purplish amygdaloidal diorite, holding epidote and jaspery red iron ore. Then follow 2000 feet of argillaceous and somewhat micaceous slates, with beds of quartzite and of limestone, generally impure. These contain, besides numerous fucoidal markings, the remains of a Lingula, and of *Olenellus Vermontanus*, a fossil characteristic of the Potsdam group. To this second division succeeds a third, consisting of about 900 feet additional of limestones and slates. Somewhat farther southward, at Great and Little Coney Arms, the lower half of the above series is not observed, but a succession of strata, supposed to represent the upper portion of the Potsdam, is more particularly described. It consists, at the base, of 300 feet of pale bluish-gray mica-slates, with iron stains, "softer, more finely laminated, and more uniform both in color and in texture" than some micaceous strata described by Mr. Murray as occurring in the Laurentian in that region. To these succeeded 430 feet of similar soft bluish-gray mica-slates, holding numerous thin seams of dark colored limestone, and followed by 1000 feet of impure limestones and slates, often micaceous and calcareous, among which are a few beds of white compact marble. No indications of fossils, save fucoidal markings, were met with in this section. At Coney-Arm Head there is seen a series of "whitish granitoid, very quartzose mica-slates," which appear to have a thickness of from 1500 to 2000 feet. The same rock is found in White Bay, where it overlies what is supposed to be Laurentian gneiss. The relations of these whitish granitic mica-slates are still obscure, but Mr. Murray was inclined to regard them as occupying a position beneath the Potsdam group. The latter, in Canada Bay, is immediately followed by the unaltered fossiliferous limestones and shales of

the Quebec group. From these investigations of Mr. Murray we learn that between the Laurentian and the Quebec group, there exists a series of several thousand feet of strata, including soft bluish-grey mica-slates and micaceous limestones, belonging to the Potsdam group; besides a great mass of whitish granitoid mica-slates, whose relation to the Potsdam is still uncertain. To the whole of these we may perhaps give the provisional name of the Terranovan series, in allusion to the name Newfoundland.

Imperfect gneisses and micaceous schists are found in several parts of the province of New Brunswick, associated with what has been described as a great granitic belt. These rocks have been examined by Prof. Hind, and by Mr. Robb, on the St. John and Mirimichi rivers; and the former of these observers some years since pointed out the indigenous character of the so-called granites. In the summer of 1869 I had an opportunity of examining, with Prof. L. W. Bailey, the region about St. Stephen, on the river St. Croix, where he had already observed a series of ferruginous quartzites and imperfect gneisses, accompanied by soft bluish mica-slates sometimes holding chiastolite, staurolite, and garnet. These highly crystalline schists are not more than five miles removed from unaltered shales of the Gaspé series, containing fossils of Upper Silurian or Lower Devonian types, and rest unconformably upon older granitoid rocks, which Prof. Bailey regards as probably Laurentian. We subsequently examined the crystalline schists of the St. John, which are apparently identical with those of the St. Croix, and these also overlie, unconformably, an older granitoid gneiss.

More recently Prof. Hind has pointed out that some of the so-called granites of Nova Scotia are ancient gneisses, probably of Laurentian age, and have shown that between these and the gold-bearing slates of that province, there is found, near Windsor, and near Sherbrooke, a series of beds of no great thickness, consisting of imperfect gneisses, quartzites and micaceous schists, which rest unconformably on the Laurentian, and are sometimes wanting altogether. These include mica-schists with chiastolite and garnet, and appear identical with those already observed by Dr. Dawson in other parts of Nova Scotia, which I had already recognized as the same with those of the White Mountains, and those of the St. Croix, just noticed. Prof. Hind, in a late paper, has called these, from their position in Nova Scotia, Huronian; but the Cambrian or Huronian rocks recognized by Messrs. Matthew and Bailey in New Brunswick, where they are widely spread along the north side of the Bay of Fundy, consist of massive diorites and quartzose feldspar-porphyries, with occasional sandstones and conglomerates, and are very unlike the gneissic and micaceous rocks in question,

which I believe to belong, like those of the St. Croix and the St. John rivers, to the great Terranovan series. The micaceous and hornblendic schists, with interstratified fine grained whitish gneisses (locally known as granites) which I have seen in Hallowell, Augusta, Brunswick and Westbrook, in Maine, appear to belong to the same series; which will also probably include much of the gneiss and mica-schist of Eastern New England. If this upper series is to be identified with the crystalline schists which, in Hastings County, Ontario, overlie, unconformably, the Laurentian, and yet contain *Eozoon Canadense*, the presence of this fossil can no longer serve to identify the Laurentian system. To this lower horizon however, I have referred a belt of gneissic rocks in Eastern Massachusetts, which are lithologically unlike the present series, and identical with the Laurentian of New York and Canada. To the upper series appear to belong the great endogenous granitic veins so well known to mineralogists as containing beryl, tourmaline and other fine crystallized minerals.

The fine-grained, white granitoid gneisses, often present an apparently bedded structure, which enables them to be removed in large plates or layers, lying at no great angle, and apparently conformable to the present surface of the country. This structure, which I conceive to have been superinduced by superficial changes of temperature, is often quite independent of the bedding, as may be seen in the quarries near Augusta in Maine, and in the cuttings on the Grand-Trunk Railway near Berlin Falls, New Hampshire. It is also observed in exotic or intrusive granites, like those of Biddeford, Maine. This is, in fact, the concentric lamination of granite, long since observed by Von Buch, and, I believe, correctly explained by Prof. N. S. Shaler to be due to movements of contraction and expansion in the mass, caused by variation of temperature during the changes of the seasons. He has not however observed this structure at greater depths than from three to five feet, while in some rocks I have found it penetrating probably twenty feet. (See Shaler's paper, read before the Boston Nat. History Society, Feb. 3, 1869, and published in the Proceedings of the Society, vol. xii, page 289).

While however I admit the existence in the Dominion of Canada and in Eastern New England, of a great series of crystalline schists, distinct from the Laurentian, and apparently the same with those found by Mr. Murray between the Laurentian and the Quebec group in Newfoundland, it is not less certain that we have in these regions rocks of Upper Silurian and Lower Devonian age, holding characteristic fossils. These strata in Maine and New Brunswick are generally but little altered. In the Connecticut valley at Bernardston, Massachu-

setts, near Lake Memphremagog in Vermont, and further northward in the province of Quebec, fossils of this horizon are found in rocks which, in some localities, are more or less altered and crystalline. I believe however that much of the calcareous mica-slate of Eastern Vermont will be found to belong to the Terranovan series. The extent of these newer rocks, and the limits between them and the more ancient schists, of the ruins of which they are probably in part composed, remain problems for farther investigation. For the solution of these, Prof. C. H. Hitchcock, by his labors in Vermont, is already well prepared, and it cannot be doubted that he, with his able assistants, will in the Survey of New Hampshire, now in progress, throw much light on New England geology. It is worthy of remark, that strata holding fossils of Lower Helderberg age, or thereabouts, are not confined to the shores of Maine and New Brunswick, and the valleys of the Connecticut and St. John rivers, but are found beyond the Green Mountains, in the valley of the St. Lawrence, near Montreal; where, on the island of St. Helen, they rest unconformably on the Utica slate, and at Belœil Mountain, near by, on intrusive diorites, which there break through the shales of the Hudson River group.

The relations of this Terranovan series to the porphyries and diorite rocks which, in New Brunswick, have been called Cambrian and Huronian by Mr. Matthew (first distinguished by him as the Coldbrook group), yet remains to be determined. These rocks are found near to the city of St. John resting directly on what has been regarded as Laurentian, and are overlaid by the uncrystalline schists which contain the primordial fauna now so well known by the descriptions of Prof. Hartt. Rocks which I regard as identical with this same Coldbrook or Cambrian group, are found along the coast of New Brunswick, and constitute the diorites and porphyries of Eastport, Maine. They appear moreover to be the same with those met with near Newburyport, and at Salem, Lynn, and Marblehead, Massachusetts. Farther researches about Passamaquoddy Bay, where the mica-slates are found not far removed from these porphyries, will probably enable us to determine their relations to each other.

It will be remembered that Gümbel has found, in Bavaria, beneath the oldest fossiliferous clay-slates, a mica-schist (and hornblende-schist) series, reposing upon the Hercynian gneiss, which contains crystalline limestones, with graphite, serpentine and *Eozoon Canadense*, and which he has identified with the Laurentian of North America. He distinguishes beneath this a great mass of red gneiss, apparently without limestones, to which he has given the name of the Bojian gneiss. It will however be remembered, that in his studies of the Laurentian system on the

Ottawa, Sir William Logan has shown that this immense series (his Lower Laurentian), some 20,000 feet in thickness, includes four great masses of gneiss and quartzite, divided by three limestone formations, and that it is in the uppermost of these, which is, in some parts, 1500 feet thick, that the *Eozoon Canadense* has been found. Some of the lower gneisses of this vast system may very well represent the Bojian of Gümbel, who has not recognized in Bavaria either the Labradorian (Upper Laurentian) or Huronian series. (See Gümbel on the Laurentian of Bavaria, translated and published in the Canadian Naturalist for December, 1866). Comparative studies of this kind should not be neglected in the investigation of our American rocks.

Montreal, May 10, 1870.